

How many people would survive if all emergency medical systems in the United States approached the hypothesized maximum survival rate of 20% that occurs in these mature EMS systems? If an estimated 3% survival rate<sup>148</sup> is applied to the presumed annual 400,000 cardiac arrests, approximately 12,000 people per year now survive out-of-hospital cardiac arrest.<sup>147</sup> A 20% survival rate for this population of nontraumatic cardiac arrest patients would yield 80,000 survivors, or an additional 68,000 people. The American Heart Association estimates that nationwide implementation of all life-saving emergency cardiac care mechanisms in each community may save between 100,000 and 200,000 lives annually in the United States.<sup>1</sup> Without proper implementation of a full prehospital care system, however, emergency services cannot achieve such rates. People not resuscitated before hospital arrival rarely survive.<sup>150,151</sup>

Figure 2. *Ventricular fibrillation survival rates over time. Percentage of people in nontraumatic cardiac arrest with initial rhythm ventricular fibrillation who survive to hospital discharge. Data from King County, Washington, Division of Emergency Medical Services, Seattle-King County Department of Public Health, Seattle.*

### Design Imitation?

Is it possible for EMS systems to imitate the design of more successful locations and thus achieve the same survival rates? [Table 3](#) summarizes data published on cardiac arrest survival from many cities worldwide.<sup>31, 33-35, 38, 39, 43, 76-90, 101, 119, 120, 142, 143, 152-158.</sup> These data show marked variation in survival rates among the different types of EMS systems, ranging from 5% to 17% survival for patients in all cardiac arrest rhythms and from 12% to 29% for patients specifically in ventricular fibrillation.

Simple structural imitation of successful EMS organizations, however, does not always succeed. Even in locations with similarly structured EMS systems, marked differences in the observed survival rates persist. For example, studies from 15 different paramedic-only or doctor-manned ambulance systems ([Table 3](#), row C) reported survival rates from 7% to 18% for all rhythms and from 13% to 30% for ventricular fibrillation.<sup>6,33-35,76-86</sup> [Table 3](#) summarizes results from nine EMT-paramedic systems (row D). These systems display the same wide variations.<sup>33,38,39,101,154-158</sup>

It is unclear exactly why these differences occur within the same types of systems. Part of the explanation is that definition of terms and reporting of data are not standardized.<sup>159</sup> While some researchers have proposed uniform reporting systems, many others have pointed to the need for an international standardized nomenclature.<sup>18,27,35,39,87,159,160</sup> Regardless, part of these differences may very well be due to variable effectiveness or lack of EMS medical leadership and direction.<sup>161-165</sup>

It can also be argued that similarly constructed systems have different survival rates because they differ in how well they develop and implement each link in the chain of survival.<sup>87,163,166</sup> This appears particularly true for early initiation of CPR and early arrival of personnel trained to operate a defibrillator. Many cities in the United States, for example, established a strong link for early advanced life support by starting paramedic services at great expense and effort.<sup>33-35,76-86</sup> Most of these paramedic-only systems have achieved disappointingly low survival rates. In part this is because citizens in these locations seldom attempted to perform CPR. In addition, long paramedic response times, in the absence of an early defibrillation program, precluded early defibrillation and early advanced care. In paramedic-only systems, paramedics are generally preoccupied with many other minor emergencies and consequently are less available (and less skilled) to deal with cardiac arrest patients.<sup>163</sup>

To strengthen the early CPR link in the chain of survival, several EMS systems have mounted extensive CPR campaigns. They have trained a large percentage of the

population in basic CPR skills. Unfortunately, these systems also have observed diminished survival rates because they failed to provide an emergency medical service with rapid defibrillation and rapid advanced life support.<sup>18,39,43,78,153,155</sup> Enhancements of early CPR programs, such as targeted CPR training<sup>10,53-59</sup> and dispatcher-assisted CPR programs,<sup>51,65,67</sup> will also fail if defibrillation does not occur soon after collapse.

Conversely, systems that have established early defibrillation programs by training their less advanced ambulance personnel to use defibrillators<sup>43,90,119,120,142</sup> may experience low success rates if they do not also train citizens to recognize cardiac arrest early or to call the emergency service immediately. The defibrillator will not arrive quickly enough if the EMS system is not called immediately, if local ambulances or first-responder units are not equipped with defibrillators, or if managers do not strategically deploy emergency response vehicles with defibrillators.

Responsible people must apply continuous quality improvement concepts to each link in the chain of survival. In early CPR, for example, it is not only a matter of the number of people who are trained. Systems can achieve better results by targeting the right groups and evaluating training programs, short-term results, and long-term trends. Automated defibrillators must be placed, then complemented with carefully planned training and follow-up programs and close medical control of the system, including individual case reviews and overall data management programs. Without these quality improvement methods, a system will not realize the full benefit of any new organization.

### Summary

The chain of survival concept embodies standard principles of system management. The phrase restates<sup>167</sup> the familiar emergency medical services continuum pioneered by Peter Safar, who coined the term *life support chain*.<sup>168</sup> Other authors have referred to the concept with various phrases.<sup>1,3,20,23,140</sup> As a pedagogic construct, it emphasizes that there are no easy, single-step approaches to improving survival from cardiac arrest.<sup>166,167</sup>

Early access to the EMS system ensures early CPR, defibrillation, and advanced care. Early access is easiest to achieve with 911 systems and widespread community education and publicity. Instructors may also teach early access during citizen CPR classes. Early CPR helps patients by slowing the process of dying, but its effectiveness disappears within minutes, and defibrillation must soon follow. Early recognition and early CPR are best achieved when citizens are well informed about cardiac emergencies and well trained in CPR. The earliest possible delivery of defibrillation is critical and almost by itself is sufficient for many victims of sudden cardiac death.

Defibrillation has therefore emerged as the single most effective intervention for patients in nontraumatic cardiac arrest. Automated external defibrillators help to accomplish this goal and permit widespread implementation of a variety of early defibrillation programs. Early advanced care helps those who do not immediately convert to an organized cardiac activity or who do not achieve a spontaneous circulation following early defibrillation. Advanced care allows the highest possible survival rate through respiratory and antiarrhythmic stabilization and monitoring of patients in the post-resuscitation period.

At present, early CPR and rapid defibrillation, combined with early advanced care, can result in long-term survival rates for witnessed ventricular fibrillation as high as 30%. Researchers have observed that neurological and psychological recovery from cardiac arrest depends on the time within which these critical interdependent treatment modalities are delivered.<sup>22,169</sup> Therefore, high resuscitation rates will also lead to a high percentage of patients who recover to the neurological level they had before their arrest.

The future of the chain of survival will be highly dependent on multicenter cooperative studies of cardiac arrest in both in-hospital and out-of-hospital settings.<sup>150,162,170</sup> In addition to scientific research, the training of those responsible for implementing and maintaining the chain of survival must become a priority.<sup>150,162,164</sup> For emergency medical services the challenge is to develop programs that will allow recognition, access, bystander CPR, defibrillation, and advanced care to occur as quickly as possible. Ideally systems should deliver these interventions within moments after sudden death victims collapse. Achievement of such a goal requires the deployment of multiple, properly directed programs, within an EMS system. Each program should lend strength to the chain of survival, thereby enhancing successful recovery and long-term survival.

### **Recommendations**

The Advanced Cardiac Life Support Subcommittee and the Emergency Cardiac Care Committee of the American Heart Association recommend that all communities take the following actions to strengthen their Chain of Survival:

#### **1. Early Access**

- All communities should implement an enhanced 911 system.
- All communities should develop education and publicity programs that focus on cardiac emergencies and a proper response by citizens.

#### **2. Early CPR**

- Communities should continue to vigorously implement and support community-wide CPR training programs.
- Community CPR programs should emphasize early recognition, early telephone contact with the EMS system, and early defibrillation.
- Community CPR programs should develop and use training methods that will increase the likelihood that citizens will actually initiate CPR.
- Communities should adopt more widespread and effective targeted CPR programs.
- Communities should implement programs to establish dispatcher-assisted CPR.

#### **3. Early Defibrillation**

- All communities should adopt the principle of early defibrillation. This principle applies to all personnel who are expected, as part of their professional duties, to perform basic CPR: they must carry an automated external defibrillator and be trained to operate it.
- Health professionals who have a duty to respond to a person in cardiac arrest should have a defibrillator available either immediately or within 1-2 minutes.
- Responsible personnel should authorize and implement more widespread use of automated external defibrillation by community responders and allied health responders.

#### **4. Early Advanced Life Support**

- Advanced life support units should be combined with first-responding units that provide early defibrillation.
- Advanced life support units should develop well-coordinated protocols that combine rapid defibrillation by first-responding units with rapid intubation and

intravenous medications by the advanced cardiac life support units.

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### References

1. Standards and guidelines for cardiopulmonary resuscitation (CPR) and emergency cardiac care (ECC). *JAMA* 1986;255:2905-2914
2. Graf WS, Polin SS, Paegel BL: A community program for emergency cardiac care: A three-year coronary ambulance-paramedic evaluation. *JAMA* 1973;226:156-160
3. Schwartz L: Pre-hospital care: Field intervention medicine, in Schwartz GR, Safar P, Stone J, Storey P, Wagner D (eds): *Principles and Practice of Emergency Medicine*. Philadelphia, WB Saunders Co, 1986, pp 593-619
4. Hallstrom AP: Improving the EMS system, in Eisenberg MS, Bergner L, Hallstrom AP (eds): *Sudden Cardiac Death in the Community*, Philadelphia, Praeger Pubs, 1984, pp 126-139
5. American Red Cross: *Adult CPR*. Boston, Mass, American National Red Cross, 1987
6. Walters G. Glucksman E: Planning a pre-hospital cardiac resuscitation programme: An analysis of community and system factors in London. *J R Coll Physicians Lond* 1989;23:107-110
7. Stults KR: Phone first. *J Emerg Med Services* 1987;12:28
8. Hunt RC, Allison EJ Jr, Yates JG III: The need for improved emergency medical services in Pitt county. *N C Med J* 1986;47:39-42
9. Hunt RC, McCabe JB, Hamilton GC, Krohmer JR: Influence of Emergency Medical Services systems and prehospital defibrillation on survival of sudden cardiac death victims. *Am J Emerg Med* 1989;7:68-82
10. Mandel LP, Cobb LA: CPR training in the community. *Ann Emerg Med* 1985;14:669-671
11. Mayron R, Long RS, Ruiz E: The 911 emergency telephone number: Impact on emergency medical systems access in a metropolitan area. *AM J Emerg Med* 1984;2:491-493
12. Eisenberg M, Hallstrom A, Becker L: Community awareness of emergency phone numbers. *Am J Public Health* 1981;71:1058-1060

13. Cummins RO, Eisenberg MS: Prehospital cardiopulmonary resuscitation: Is it effective? *JAMA* 1985;253:2408-2412
14. Thompson BM, Stueven HA, Mateer JR, Aprahamian CC, Tucker JF, Darin JC: Comparison of clinical CPR studies in Milwaukee and elsewhere in the United States. *Ann Emerg med* 1985;14:750-754
15. Kowalski R, Thompson BM, Horwitz L, Stueven H, Aprahamian C, Darin JC: Bystander CPR in prehospital coarse ventricular fibrillation. *Ann Emerg Med* 1984;13:1016-1020
16. Kouwenhoven WB, Jude JR, Knickerbocker GG: Closed-chest cardiac massage. *JAMA* 1960;173:1064-1067
17. Safar P, Brown TC, Holtey WJ, Wilder RJ: Ventilation and circulation with closed-chest cardiac massage in man. *JAMA* 1961;176:574-576
18. Bossaert L, Van Hoeyweghen R, Cerebral Resuscitation Study Group: Bystander cardiopulmonary resuscitation (CPR) in out-of-hospital cardiac arrest. *Resuscitation* 1989;17(suppl):S55-S69
19. Cummins R, Graves J: Clinical results of standard CPR: Prehospital and in-hospital, in Kaye W, Bircher N (eds): *Cardiopulmonary Resuscitation*. New York, Churchill Livingstone, Inc., 1989, pp 87-102
20. Advanced cardiac life support in perspective, in *Textbook of Advanced Cardiac Life Support*. Dallas, American Heart Association, 1987, pp 1-10
21. Safar P: History of cardiopulmonary-cerebral resuscitation, in Kaye W, Bircher N (eds): *Cardiopulmonary Resuscitation*. New York, Churchill Livingstone, Inc, 1989, pp 1-54
22. Pepe P: Advanced cardiac life support: State of the art, in Vincent JL (ed): *Emergency and Intensive Care*. Berlin, Springer-Verlag, 1990, pp 565-585
23. Putting it all together: Resuscitation of the patient, in *Textbook of Advanced Cardiac Life Support*. Dallas, American Heart Association, 1987, pp 235-248
24. Eisenberg M, Bergner L, Hallstrom A: Paramedic programs and out-of-hospital cardiac arrest: I. Factors associated with successful resuscitation. *Am J Public Health* 1979;69:30-38
25. Carrington D: Heartstart Scotland: Early defibrillation for the whole of Scotland, in *Proceedings of the 6th World Congress on Disaster and Emergency Medicine*. Hong Kong, Excerpta Medica, 1989, p 66
26. Pepe P: Presumptive diagnosis of death versus whom to resuscitate, in Kuehl A (ed): *EMS Medical Director's Handbook for the National Association of EMS Physicians*. St. Louis, CV Mosby Co, 1989, pp 275-289
27. Mullie A, Van Hoeyweghen R, Quets A, Cerebral Resuscitation Study Group: Influence of time intervals on outcome of CPR. *Resuscitation* 1989;17(suppl):S23-S33
28. Lund I, Skulberg A: Cardiopulmonary resuscitation by lay people. *Lancet* 1976;2:702-704

29. Copley DP, Mantle JA, Rogers WJ, Russell RO Jr: Improved outcome for prehospital cardiopulmonary collapse with resuscitation by bystanders. *Circulation* 1977;56:901-905
30. Thompson RG, Hallstrom AP, Cobb LA: Bystander-initiated cardiopulmonary resuscitation in the management of ventricular fibrillation. *Ann Intern Med* 1979;90:737-740
31. Tweed WA, Bristow G, Donen N: Resuscitation from cardiac arrest: Assessment of a system providing only basic life support outside of hospital. *Can Med Assoc J* 1980;122:297-300
32. Gudjonsson H, Baldvinsson E, Oddsson G, Asgeirsson E, Kristjansson H, Hardarson T: Results of attempted cardiopulmonary resuscitation of patients dying suddenly outside the hospital in Reykjavik and the surrounding area, 1976-1979. *Acta Med Scand* 1982;212:247-251
33. Vertesi L, Wilson L, Glick N: Cardiac arrest: Comparison of paramedic and conventional ambulance services. *Can Med Assoc J* 1983;128:809-812
34. Guzy PM, Pearce ML, Greenfield S: The survival benefit of bystander cardiopulmonary resuscitation in a paramedic-served metropolitan area. *Am J Public Health* 1983;73:766-769
35. Roth R, Stewart RD, Rogers K, Cannon GM: Out-of-hospital cardiac arrest: Factors associated with survival. *Ann Emerg Med* 1984;13:237-243
36. Stueven H, Troiano P, Thompson B, Mateer JR, Kastenson EH: Bystander/first responder CPR: Ten years experience in a paramedic system. *Ann Emerg Med* 1986;15:707-710
37. Ritter G, Wolfe RA, Goldstein S, Landis JR, Vasu CM, Acheson A, Leighton R, Medendorp SV: The effect of bystander CPR on survival of out-of-hospital cardiac arrest victims. *Am Heart J* 1985;110:932-937
38. Cummins RO, Eisenberg MS, Hallstrom AP, Litwin PE: Survival of out-of-hospital cardiac arrest with early initiation of cardiopulmonary resuscitation. *Am J Emerg Med* 1985;3:114-119
39. Eitel DR, Walton SL, Guerri AD, Hess DR, Sabulsky NK: Out-of-hospital cardiac arrest: A six-year experience in a suburban-rural system. *Ann Emerg Med* 1988;17:808-812
40. Spaite DW, Hanlon T, Criss EA, Valenzuela TD, Wright AL, Keeley KT, Meislin HW: Prehospital cardiac arrest: The impact of witnessed collapse and bystander CPR in a metropolitan EMS system with short response times. *Ann Emerg Med* 1990;19:1264-1269
41. Lewi PJ, Mullie A, Quets A: Relevance and significance of pre-CPR conditions in cardiopulmonary-cerebral resuscitation: A graphic analysis by means of Spectramap. *Resuscitation* 1989;17(suppl):S35-S44
42. Wright D, James C, Marsden AK, Mackintosh AF: Defibrillation by ambulance staff who have had extended training. *BMJ* 1989;299:96-97
43. Jakobsson J, Nyquist O, Rehnqvist N: Cardiac arrest in Stockholm with special reference to the ambulance organization. *Acta Med Scand* 1987;222:117-122



44. Weaver WD, Cobb LA, Dennis D, Ray R, Hallstrom AP, Copass MK: Amplitude of ventricular fibrillation waveform and outcome after cardiac arrest. *Ann Intern Med* 1985;102:53-55
45. Selby ML, Kautz JA, Moore TJ, Gombeski WR Jr, Ramirez AG, Farge EJ, Forthofer RN: Indicators of response to a mass media CPR recruitment campaign. *Am J Public Health* 1982;72:1039-1042
46. St. Louis P, Carter WB, Eisenberg MS: Prescribing CPR: A survey of physicians. *Am J Public Health* 1982;72:1158-1160
47. Goldberg RJ: Physicians and CPR training in high-risk family members. *Am J Public Health* 1987;77:671-672
48. Cobb LA, Werner JA, Trobaugh GB: Sudden cardiac death: I. A decade's experience with out-of-hospital resuscitation. *Mod Concepts Cardiovasc Dis* 1980;49:31-36
49. Murphy RJ, Luepker RV, Jacobs DR Jr, Gillum RF, Folsom AR, Blackburn H: Citizen cardiopulmonary resuscitation training and use in a metropolitan area; The Minnesota Heart Survey. *Am J Public Health* 1984;74:513-515
50. Gombeski WR Jr, Effron DM, Ramirez AG, Moore TJ: Impact on retention: Comparison of two CPR training programs. *Am J Public Health* 1985;72:849-852
51. Eisenberg MS, Hallstrom AP, Carter WB, Cummins RO, Bergner L, Pierce J: Emergency CPR instruction via telephone. *Am J Public Health* 1985;75:47-50
52. McCormack AP, Damon SK, Eisenberg MS: Disagreeable physical characteristics affecting bystander CPR. *Ann Emerg Med* 1989;18:283-285
53. Cobb LA, Hallstrom AP, Thompson RG, Mandel LP, Copass MK: Community cardiopulmonary resuscitation. *Annu Rev Med* 1980;31:453-462
54. Cobb LA, Hallstrom AP: Community-based cardiopulmonary resuscitation: What have we learned? *Ann N Y Acad Sci* 1982;382:330-342
55. Bossaert L, Van Hoeyweghen R, Cerebral Resuscitation Study Group: Evaluation of cardiopulmonary resuscitation (CPR) techniques. *Resuscitation* 1989;17(suppl):S99-S109
56. Murphy RJ, Luepker RV, Jacobs DR Jr, Gillum RF, Folsom AR, Blackburn H: Citizen cardiopulmonary resuscitation training and use in a metropolitan area: The Minnesota Heart Survey. *Am J Public Health* 1984;74:513-515
57. Goldberg RJ, Gore JM, Love DG, Ockene JK, Dalen JE: Layperson CPR – Are we training the right people? *Ann Emerg Med* 1984;13:701-704
58. Pane G, Salness K: Targeted recruitment of senior citizens and cardiac patients to a mass CPR training course. *Ann Emerg Med* 1989;18:152-154
59. Pane GA, Salness KA: A survey of participants in a mass CPR training course. *Ann Emerg Med* 1987;16:1112-1116
60. Litwin PE, Eisenberg MS, Hallstrom AP, Cummins RO: The location of collapse and its effect on survival from cardiac arrest. *Ann Emerg Med* 1987;16:787-791

61. Kraus JF, Borhani NO, Franti CE: Socioeconomic status, ethnicity and risk of coronary heart disease. *Am J Epidemiol* 1980;111:407-414
62. Eisenberg MS: Who shall live? Who shall die? in Eisenberg MS, Bergner L, Hallstrom AP (eds): *Sudden Cardiac Death in the Community*. Philadelphia, Praeger Pubs, 1984, pp 44-58
63. Bonnin M, Pepe P, Clack P: Survival prognosis for the elderly after out-of-hospital cardiac arrest (abstract). *Ann Emerg Med* 1989;18:469
64. Safar P, Abramson N, Detre K: Old age does not negate good outcome after cardiac arrest and CPR (abstract). *Crit Care Med* 1989;17:575
65. Carter WB, Eisenberg MS, Hallstrom AP, Schaeffer S: Development and implementation of emergency CPR instructions via telephone. *Ann Emerg Med* 1984;13:695-700
66. Clawson JJ: Emergency medical dispatching, in Roush WR, Aranosian RD, Blair TMH, Handal KA, Kellow RD, Stewart RD (eds): *Principles of EMS Systems: A Comprehensive Text for Physicians*. Dallas, American College of Emergency Physicians, 1989, pp 119-133
67. Kellerman AL, Hackman BB, Somes G: Dispatcher-assisted cardiopulmonary resuscitation: Validation of efficacy. *Circulation* 1989;80:1231-1239
68. Bayés de Luna A, Coumel P, Leclercq JF: Ambulatory sudden cardiac death: Mechanisms of production of fatal arrhythmia on the basis of data from 157 cases. *Am Heart J* 1989;117:151-159
69. Fletcher GF, Cantwell JD: Ventricular fibrillation in a medically supervised cardiac exercise program: Clinical, angiographic, and surgical correlations. *JAMA* 1977;238:2627-2629
70. Haskell WL: Cardiovascular complications during exercise training of cardiac patients. *Circulation* 1978;57:920-924
71. Hossack KF, Hartwig R: Cardiac arrest associated with supervised cardiac rehabilitation. *J Cardiac Rehab* 1982;2:402-408
72. Van Camp SP, Peterson RA: Cardiovascular complications of outpatient cardiac rehabilitation programs. *JAMA* 1986;256:1160-1163
73. Colquhoun MC: Use of defibrillators by general practitioners. *BMJ* 1988;297:336-337
74. Rawlins DC: Study of the management of suspected cardiac infarction by British immediate care doctors. *Br Med J [Clin Res]* 1981;282:1677-1697
75. Pai GR, Haites NE, Rawles JM: One thousand heart attacks in Grampian: The place of cardiopulmonary resuscitation in general practice. *Br Med J [Clin Res]* 1987;294:352-354
76. Amey BD, Harrison EE, Straub EJ: Sudden cardiac death: A retrospective and prospective study. *JACEP* 1976;5:429-433
77. Bachman JW, McDonald GS, O'Brien PC: A study of out-of-hospital cardiac



arrests in northeastern Minnesota. *JAMA* 1986;256:477-483

78. Crawford GC, Denton M, Fisher CA, Giaoniz IL, Sharpe N, Scragg R: Resuscitation outside hospital in Auckland, *N Z Med J* 1986;99:452-455

79. Diamond NJ, Schofferman J, Elliott JW: Factors in successful resuscitation by paramedics. *JACEP* 1977;6:42-46

80. Eisenberg MS, Hadas E, Nuri I, Applebaum D, Roth A, Litwin PE, Hallstrom A, Nagel E: Sudden cardiac arrest in Israel: Factors associated with successful resuscitation. *Am J Emerg Med* 1988;6:319-323

81. Goldstein S, Landis JR, Leighton R, Ritter G, Vasu CM, Lantis A, Serokman R: Characteristics of the resuscitated out-of-hospital cardiac arrest victim with coronary heart disease. *Circulation* 1981;64:977-984

82. Lauterbach SA, Spadafora M, Levy R: Evaluation of cardiac arrest managed by paramedics. *J Am Coll Emerg Med* 1978;7:355-357

83. Liberthson RR, Nagel EL, Hirschman JC, Nussenfeld JD: Prehospital ventricular defibrillation: Prognosis and follow-up course. *N Engl J Med* 1974;291:317-321

84. Mackintosh AF, Crabb ME, Grainger R, Williams JH, Chamberlain DA: The Brighton resuscitation ambulances: Review of 40 consecutive survivors of out-of-hospital cardiac arrest. *Br Med J [Clin Res]* 1978;1:1115-1118

85. McSwain GR, Garrison WB, Artz CP: Evaluation of resuscitation from cardiopulmonary arrest by paramedics. *Ann Emerg Med* 1980;9:341-345

86. Rose LB: The Oregon Coronary Ambulance Project: An experiment. *Heart Lung* 1974;3:753-755

87. Eisenberg MS, Horwood BT, Cummins RO, Reynolds-Haertle R, Hearne TR: Cardiac arrest and resuscitation: A tale of 29 cities. *Ann Emerg Med* 1990;19:179-186

88. Eisenberg MS, Copass MK, Hallstrom AP, et al: Treatment of out-of-hospital cardiac arrest with rapid defibrillation by emergency medical technicians *N Engl J Med* 1980;302:1379-1383

89. Eisenberg MS, Hallstrom AP, Copass MK, Bergner L, Short F, Pierce J: Treatment of ventricular fibrillation: Emergency medical technician defibrillation and paramedic services. *JAMA* 1984;251:1723-1726

90. Stults KR, Brown DD, Schug VL, Bean JA: Prehospital defibrillation performed by emergency medical technicians in rural communities. *N Engl J Med* 1984;310:219-223

91. Weaver WD, Copass MK, Bui D, Ray R, Hallstrom AP, Cobb LA: Improved neurologic recovery and survival after early defibrillation. *Circulation* 1984;69:943-948

92. White RD: EMT-defibrillation: Time for controlled implementation of effective treatment. *Emerg Cardiac Care Newsletter* 1986;8:1-3

93. Cummins RO: EMT-defibrillation: National guidelines for implementation. *Am J*

*Emerg Med* 1987;5:254-257

94. Cummins RO, Eisenberg MS, Moore JE, Hearne TR, Andresen E, Wendt R, Litwin PE, Graves JR, Hallstrom AP, Pierce J: Automatic external defibrillators: Clinical, training, psychological, and public health issues. *Ann Emerg Med* 1985;14:755-760
95. Cummins RO: From concept to standard-of-care? Review of the clinical experience with automated external defibrillators. *Ann Emerg Med* 1989;18:1269-1275
96. Cummins RO, Eisenberg MS, Bergner L, Hallstrom AP, Hearne T, Murray JA: Automatic external defibrillation: Evaluations of its role in the home and in emergency medical services. *Ann Emerg Med* 1984;13(9, pt 2):789-801
97. Cummins RO, Eisenberg MS, Stults KR, Automatic external defibrillators: Clinical issues for cardiology. *Circulation* 1986;73:381-385
98. Cummins RO, Eisenberg MS, Litwin PE, Graves JR, Hearne TR, Hallstrom AP: Automatic external defibrillators used by emergency medical technicians: A controlled clinical trial. *JAMA* 1987;257:1605-1610
99. Stults KR, Brown DD, Kerber RE: Efficacy of an automated external defibrillator in the management of out-of-hospital cardiac arrest; Validation of the diagnostic algorithm and initial experience in a rural environment. *Circulation* 1986;73:701-709
100. Paris PM: EMT-defibrillation: A recipe for saving lives. *Am J Emerg Med* 1988;6:282-287
101. Weaver WD, Cobb LA, Hallstrom AP, Copass MK, Ray R, Emery M, Fahrenbruch C: Considerations for improving survival from out-of-hospital cardiac arrest. *Ann Emerg Med* 1986;15:1181-1186
102. Atkins J, Streigler H, Burstain T, Foster G: Improved survival rates with automatic defibrillators (abstract). *Prehospital Disaster Med* 1989;1:69
103. Cummins RO, Stults KR, Haggard B, Kerber RE, Schaeffer S, Brown DD: A new rhythm library for testing automatic external defibrillators: Performance of three devices. *J Am Coll Cardiol* 1988;11:597-602
104. Bocka JJ: Automatic external defibrillators. *Ann Emerg Med* 1989;18:1264-1268
105. Edwards DG: Development of a decision algorithm for a semiautomatic defibrillator. *Ann Emerg Med* 1989;18:1276-1279
106. Stults KR, Cummins RO: Fully automatic vs. shock advisory defibrillators: What are the issues? *J Emerg Med Services* 1987;71-73
107. Newman MM: Advancing resuscitation abroad. *J Emerg Med Services* 1987;12:22-26
108. Newman MM: An international movement for earlier defibrillation. *J Emerg Med Services* 1988;13:19-21
109. Fonsmark L, Sandøe E, Kastrup J, Svendsen JH: Treatment of cardiac arrest

outside of the hospital with a semiautomatic defibrillator – Heartstart 2000. *Ugeskr Laeger* 1989;151:1048-1051

110. Hapnes S: The chain of survival: The Scandinavian experience, in *Proceedings of the 6th World Congress on Disaster and Emergency Medicine*. Hong Kong, Excerpta Medica, 1989, p 43

111. Bett JH: Experience with a mobile coronary care unit in Brisbane. *Ann Emerg Med* 1989;18:969-974

112. Anatharaman V, Koo C, Tan T: Pre-hospital cardiac defibrillation programme in Singapore, in *Proceedings of the 6th World Congress on Disaster and Emergency Medicine*. Hong Kong, Excerpta Medica, 1989, p 44

113. Newman MM: Defibrillation shakes the nation: Results of the Journal of Emergency Medical Services 1988 National Early Defibrillation Study. *J Emerg Med Services* 1989;14:50-59

114. Newman MM: The survival advantage: Early defibrillation programs in the fire service. *J Emerg Med Services* 1987;12:40-46

115. Murphy DM: Rapid defibrillation: Fire service to lead the way. *J Emerg Med Services* 1987;12:67-71

116. Murphy DM: RapidZap, in Graves JR, Austin DJ, Cummins RO (eds): *RapidZap: Automatic Defibrillation*. Englewood Cliffs, NJ, Brady Communications Co, Inc, 1989, pp 1-3

117. IAFC on Scene, *Newsletter, International Association of Fire Chiefs*. Washington, DC, 1987, p 1

118. Dibbs E, Thomas HE Jr, Weiss ST, Sparrow D: Fire fighting and coronary heart disease. *Circulation* 1982;65:943-946

119. Vukov LF, White RD, Bachman JW, O'Brien PC: New perspective on rural EMT defibrillation. *Ann Emerg Med* 1988;17:318-321

120. Gray AJ, Redmond AD, Martin MA: Use of the automatic external defibrillator - pacemaker by ambulance personnel: The Stockport experience. *Br Med J [Clin Res]* 1987;294:1133-1135

121. Gentile D, Auerbach P, Gaffron J, Foon G, Phillips J Jr: Prehospital defibrillation by emergency medical technicians: Results of a pilot study in Tennessee. *J Tenn Med Assoc* 1988;81:144-148

122. Olson DW, LaRochelle J, Fark D, Aprahamian C, Aufderheide TP, Mateer JR, Hargarten KM, Stueven HA: EMT-defibrillation: The Wisconsin experience. *Ann Emerg Med* 1989;18:806-811

123. Jacobs L: Medical, legal, and social implications of automatic external defibrillators. *Ann Emerg Med* 1986;15:863-864

124. Hallstrom AP, Eisenberg MS, Bergner L: The potential use of automatic defibrillators in the home for management of cardiac arrest. *Med Care* 1984;22:1083-1087

125. Eisenberg MS, Cummins RO: Automatic external defibrillation: Bringing it home. *Am J Emerg Med* 1984;3:568-569
126. Moore JE, Eisenberg MS, Cummins RO, Hallstrom A, Litwin P, Carter W: Lay person use of automatic external defibrillation. *Ann Emerg Med* 1987;16:669-672
127. McDaniel CM, Berry VA, Haines DE, DiMarco JP: Automatic external defibrillation of patients after myocardial infarction by family members: Practical aspects and psychological impact of training. *PACE* 1988;11:2029-2034
128. Cummins RO, Schubach JA, Litwin PE, Hearne TR: Training lay persons to use automatic external defibrillators: Success of initial training and one-year retention of skills. *Am J Emerg Med* 1989;7:143-149
129. Chadda KD, Kammerer R: Early experiences with the portable automatic external defibrillator in the home and public places. *Am J Cardiol* 1987;60:732-733
130. Chadda KD, Kammerer RJ, Kuphal J, Miller K: Successful defibrillation in the industrial, recreational and corporate settings by laypersons (abstract). *Circulation* 1987;76(suppl IV):IV-12
131. Swenson RD, Hill DL, Martin JS, Wirkus M, Weaver WD: Automatic external defibrillators used by family members to treat cardiac arrest (abstract). *Circulation* 1987;76(suppl IV):IV-463
132. Eisenberg MS, Moore J, Cummins RO, Andresen E, Litwin PE, Hallstrom AP, Hearne T: Use of the automatic external defibrillator in home or survivors of out-of-hospital ventricular fibrillation. *Am J Cardiol* 1989;63:443-446
133. Weaver WD, Sutherland K, Wirkus MJ, Bachman R: Emergency medical care requirements for large public assemblies and a new strategy for managing cardiac arrest in this setting. *Ann Emerg Med* 1989;18:155-160
134. Chapman PJC, Chamberlain DA: Death in the clouds. *Br Med J [Clin Res]* 1987;294:181
135. Gessman LJ, Li JK-J, Lewandowski J, Yamazaki H, Helfant RH: Transtelephonic resuscitation: A new approach to sudden death (abstract). *Am J Cardiol* 1979;43:422
136. Ruffy R, Gessman LJ, Barbey JT, Allen ET, Smith M, Steinberg S: Pilot study of transtelephonic cardioversion/defibrillation in man. *Circulation* 1987;76(suppl IV):IV-463
137. Dalzell GW, Cunningham SR, Prouzina S, Anderson J, Magee H, Adgey AA: Assessment of a device for transtelephonic control of defibrillation. *Lancet* 1988;1:695-697
138. Herlitz B, Lebow F: Telephonic defibrillator helps close "critical window." *Emergency Medical News* 1989;26:29
139. Associated Press: Portable defibrillator saves woman stricken at home. *Seattle Times*, July 7, 1989, B-3
140. Atkins JM: Emergency medical service systems in acute cardiac care: State of the art. *Circulation* 1986;74(suppl IV):IV-4-IV-8

141. Cummins RO, Graves JR, Horan S, Larsen MP, Crump K: The relative contributions of early defibrillation and ACLS interventions to resuscitation and survival from prehospital cardiac arrest (abstract). *Ann Emerg Med* 1989;18:468-469
142. Eisenberg MS, Bergner L, Hallstrom A: Out-of-hospital cardiac arrest: Improved survival with paramedic services. *Lancet* 1980;1:812-815
143. Weaver WD, Hill D, Fahrenbruch CE, Copass MK, Martin JS, Cobb LA, Hallstrom AP: Use of the automatic external defibrillator in the management of out-of-hospital cardiac arrest. *N Engl J Med* 1988;319:661-666
144. Ishida T: Prognosis of cardiac arrest patients and proposals for improved outcomes, in *Proceedings of the 6<sup>th</sup> World Congress on Disaster and Emergency Medicine*. Hong Kong, Excerpta Medica, 1989, p 43
145. Oxer H: Strengthening the chain of survival: Australia, in *Proceedings of the 6th World Congress on Disaster and Emergency Medicine*. Hong Kong, Excerpta Medica, 1989, p 44
146. Moles M: Travel light, travel fast: Motorcycle paramedics in Hong King. *Prehospital Disaster Med* 1989;4:179
147. 1987 *Heart Facts*. Dallas, American Heart Association, 1986, p 31
148. Eisenberg MS, Bergner L, Hallstrom AP, Cummins RO: Sudden cardiac death. *Sci Am* 1986;254:37-43
149. Cummins RO, Graves JR: Prehospital transcutaneous pacing by paramedics and emergency medical technicians: Clinical and system effectiveness. *Prehospital Disaster Med* 1989;4:196
150. Bonnin M, Pepe P: Key role of prehospital resuscitation in survival from out-of-hospital cardiac arrest (abstract). *Ann Emerg Med* 1990;19:466
151. Kellermann AL, Staves DR, Hackman BB: In-hospital resuscitation following unsuccessful prehospital advanced cardiac life support: "Heroic efforts" or an exercise in futility? *Ann Emerg Med* 1988;17:589-594
152. Wilson BH, Severance HW Jr, Raney MP, Pressley JC, McKinnis RA, Hindman MC, Smith M, Wagner GS: Out-of hospital management of cardiac arrest by basic emergency medical technicians. *Am J Cardiol* 1984;53:68-70
153. Holmberg S, Wennerblom B: Out-of-hospital cardiac arrest: Effect of special ambulances I Göteborg on mortality. *Am J Emerg Med* 1984;2:222-224
154. Lewis RP, Stang JM, Warren JV: The role of paramedics in resuscitation of patients with prehospital cardiac arrest from coronary artery disease. *Am J Emerg Med* 1984;2:200-203
155. Pressley JC, Raney MP, Wilson BH, Severance HW, Wagner GS: Assessment of out-of-hospital resuscitation. *Am J Emerg Med* 1984;2:215-216
156. Stueven H, Troianop P, Thompson B, Mateer JR, Kastenson EH, Tonsfeldt D, Hargarten K, Kowalski R, Aprahamian C, Darin J: Bystander/first responder CPR: Ten years experience in a paramedic system. *Ann Emerg Med* 1986;15:707-710

157. Rockswold G, Sharma B, Ruiz E, Asinger R, Hodges M, Brieter M: Follow-up of 514 consecutive patients with cardiopulmonary arrest outside the hospital. *JACEP* 1979;8:216-220
158. Sammel NL, Taylor K, Selig M, O'Rourke MF: New South Wales intensive care ambulance system: Outcome of patients with ventricular fibrillation. *Med J Aust* 1981;2:546-550
159. Eisenberg MS, Cummins RO, Damon S, Larsen MP, Hearne TR: Survival rates from out-of-hospital cardiac arrest: Recommendations for uniform definitions and data to report. *Ann Emerg Med* 1990;19:1249-1259
160. Eisenberg MS, Bergner L, Hearne T: Out-of-hospital cardiac arrest: A review of major studies and a proposed uniform reporting system. *Am J Public Health* 1980;70:236-240
161. Pepe P: The past, present and future of emergency medical services. *Prehospital Disaster Med* 1989;4:47-49
162. Pepe P, Bonnin M, Mattox K: Regulating the scope of EMS. *Prehospital Disaster Med* 1990;5:59-63
163. Pepe P, Bonnin M, Almaquer D, Prentice F, Mattox K: The effect of tiered system implementation on sudden death survival rates. *Prehospital Disaster Med* 1989;4:71
164. Pepe P, Mattox K, Prentice F: Impact of full-time physician supervision on an urban emergency medical services system (abstract). *Prehospital Disaster Med* 1989;5:70
165. Pepe P, Copass M, Joyce T: Prehospital endotracheal intubation – The rationale for training emergency medical personnel. *Ann Emerg Med* 1985;14:1085-1092
166. Newman MM: Early access, early CPR and early defibrillation: Cry of the 1988 Conference on Citizen CPR. *J Emerg Med Services* 1988;13:30-35
167. Newman MM: Chain of Survival concept takes hold. *J Emerg Med Services* 1989;14:11-13
168. Safar P, Bircher N: History and phases and stages of cardiopulmonary cerebral resuscitation, in Safar P, Bircher N (eds): *Cardiopulmonary Cerebral Resuscitation*, ed 3. Philadelphia, WB Saunders Co, 1988
169. Abramson N, Safar P, Detre K, Group BIS: Factors influencing neurologic recovery after cardiac arrest (abstract). *Ann Emerg Med* 1989;18:477-478
170. Pepe P: Controlled studies in the prehospital setting: A viable important venue for clinical research. *Prehospital Disaster Med* (in press)

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